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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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MISSOURI HEADWATERS BASIN
BOOT LAKE DAM
BEAVERHEAD COUNTY, MONTANA
MT-823

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PREPARED FOR:

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

BEAVERHEAD WATER COMPANY
(OWNER/OPERATOR)

PREPARED BY:
HOSKINS-WESTERN-SONDEREGGER, INC.

MARCH, 1981

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the owner and the State of Montana Department of Natural Resources and Conservation, Boot Lake Dam was inspected by Hoskins-Western-Sonderegger, Inc., on 20 September 1979, under the authority of Public Law 92-367. Boot Lake Dam is located in Beaverhead County, Montana, approximately 22 miles northwest of Dillon.

This report was compiled from information obtained during an on-site inspection, a review of operation records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

Boot Lake Dam is one of four dams in the Birch Creek watershed, owned and operated by the Beaverhead Water Company, which are used for irrigation storage. The other dams are Anchor Lake Dam, Tub Lake Dam, and Pear Lake Dam, all of which are upstream of Boot Lake Dam. The Boot Lake project consists of a natural lake and an embankment to raise the lake elevation for irrigation storage. The reservoir has a drainage area of 3.0 square miles (including upstream reservoirs), surface area of about 57 acres at normal pool, and storage at dam crest of 1150 acre-feet. The project is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1981.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 27-foot-high Boot Lake Dam (MT-823) is classified as being of intermediate size and as having a significant (Category 2) downstream hazard potential, due to the presence of approximately 2 inhabitable structures located about 10 miles downstream from the dam on Birch Creek.

Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of one-half the probable maximum flood (PMF) to the PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Due to the distance from the dam to the affected structures, we recommend that the SDF for Boot Lake Dam be one-half of the PMF.

During the dam safety analysis, an estimated PMF was developed for the drainage basin resulting from a 24-hour storm. The resulting PMF for the entire 3.0-square-mile watershed has a volume of approximately 2500 acre-feet. The reservoir level at the beginning of the 24-hour storm was assumed to be at the elevation of the top of the flashboards. Infiltration losses were assumed to be zero. Reservoir routings of the estimated 24-hour PMF indicate that the project will handle about 11% of the PMF volume before

overtopping if the low-level outlet is fully closed, or about 17% of the PMF volume before overtopping if the low-level outlet is fully open. The dam is constructed of materials that will probably erode and fail when overtopped by flood waters.

On the basis of the field inspection and the study of hydrologic and operational data, Boot Lake Dam does not conform to inspection guidelines with respect to discharge and/or storage capacity to safely handle the recommended SDF.

Evidence of foundation or abutment seepage was found at the downstream toe and in the abutment troughs. Evidence of concentrated seepage through the embankment was found above and to the left of the low-level outlet headwall, on the downstream slope. This embankment seepage could lead to embankment failure by piping. No piezometers are installed to measure water levels in the embankment, and there is no known internal drainage system. Sufficient information is not available upon which to base an evaluation of the stability of the embankment.

PRINCIPAL RECOMMENDATIONS

Due to storage between the normal pool and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety without decreasing this existing flood protection.

A downstream warning plan, for use in the event of possible embankment failure, needs to be developed and placed into operation immediately. All debris needs to be removed from the reservoir, the spillway approach channel, and the upstream face of the dam. The spillway log boom needs to be repaired or replaced. The conduit inlet structure wing walls need to be repaired or replaced, and the concrete top slab on the valve tower needs to be replaced. A formal maintenance program needs to be established.

A discussion of all of the many alternatives which exist for failure or overtopping of the dams and reservoirs and the responses to these failures or overtoppings by downstream dams and reservoirs in this watershed is very complex and beyond the scope of this preliminary study. It is recommended that additional, more-detailed studies be initiated on this watershed so that a better understanding of the complex situation is achieved. In addition, analyses should be performed by a qualified geotechnical engineer experienced in dam design and construction to determine whether the embankment requires modification to provide adequate stability. Modify the project as these studies indicate.

Prior to performing engineering studies and/or remedial construction, coordinate work with the U. S. Forest Service and the Department of Natural Resources and Conservation to insure compliance with all laws and regulations.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID. No.	MT-823
Owner	Beaverhead Water Company
Operator	Same
Purpose	Irrigation
Location	Section 4, T5S, R11W Beaverhead County, Montana
Watershed	Tributary to Birch Creek
Downstream Hazard Potential	Significant
USGS Quadrangle	Torrey Mountain, Montana

2. RESERVOIR

Surface Area at Normal Pool (Top of Timber Flashboards)	57 acres
Normal Storage (Top of Timber Flashboards)	980 acre-feet
Total Storage (Min. Dam Crest)	1150 acre-feet
Surcharge Storage	170 acre-feet
Drainage Area	3.0 square miles
Reservoir Water Surface Elev. (9/20/79)	8228.1 feet (NGVD)

3. SPILLWAY

Type	Uncontrolled earth and rock channel, with concrete crest structure and timber flashboards
Crest Elevation (Top of Timber Flashboards)	8244.4 feet (NGVD)
Crest Elevation (Concrete Crest Structure)	8241.0 feet (NGVD)
Width (Crest)	22 feet
Spillway Capacity (Min. Dam Crest)	370 cfs

4. OUTLET WORKS

Type	Controlled, welded steel pipe
Controls	Slide gate with manual control from dam crest
Size	2 pipes, both 24-inch diameter
Length	130 feet
Inlet Invert	8224.0 feet (NGVD)
Outlet Invert	8220.0 feet (NGVD)
Normal Tailwater	8220.0 feet (NGVD)
Discharge Capacity (Min. Dam Crest)	130 cfs

5. DAM

Type	Earth
Maximum Height (Hydraulic)	27 feet
Crest Length	288 feet
Crest Elevation (Min.)	8247.3 feet (NGVD)
Crest Width	22 feet
Upstream Slope	1(V) on 4(H)
Downstream Slope	1(V) on 2.6(H)

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and elevation of Boot Lake Dam, owned and operated by the Beaverhead Water Company of Dillon, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate

project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and an interview with the owners. Records of infrequent inspection, dating as far back as 1947, were furnished for reference. No design drawings or foundation exploration results were available for review or analysis. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers;
Art Taylor, Civil Engineer, State of Montana, Department of Natural Resources and Conservation; and
Garth Taylor, President, Beaverhead Water Company.

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Mike McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of the Beaverhead Water Company, the U.S. Forest Service, the Bureau of Land Management, and the Montana Department of Natural Resources and Conservation. Their written comments have been included in the Appendix of this report.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Boot Lake is one of four high mountain lakes, owned and operated by the Beaverhead Water Company, which are used to store snowmelt and runoff for irrigation. It is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1891. Anchor Lake (drainage area = 0.46 square miles) and Tub Lake (drainage area = 0.25 square miles) discharge into Pear Lake (local drainage area = 0.76 square miles) which drains into Boot Lake (local drainage = 1.53 square miles). The total area of the entire watershed is about 3.0 square miles.

Boot Lake is a natural lake which was modified by the construction of a dam across the natural outlet in 1912. There is infrequent recreational use of the lake. The lake and dam are located in Section 4, Township 5 S, Range 11 W, Beaverhead County, Montana, on Birch Creek, approximately 22 miles northwest of Dillon. A 22-foot-wide uncontrolled spillway for the facility is located in the right abutment of the dam. The low-level outlet for the dam is a pair of gated, 24-inch welded steel pipes, which are used to control the amount of discharge from the lake during the irrigation season.

Boot Lake Dam is 27 feet high and, at the minimum dam crest elevation of 8247.3 feet, impounds approximately 1,150 acre-feet of water with a surface area of about 59 acres. Based on a visual reconnaissance and engineering judgment, approximately 2 inhabitable structures located about 10 miles downstream from the dam on Birch Creek could be affected by a sudden breach of the dam. The dam, therefore, is classified as intermediate in size and as having significant downstream hazard potential.

1.2.2 Regional Geology

Boot Lake Dam is in the Pioneer Mountains, which are in the southwest corner of Montana. The Pioneer Mountains are bounded by the Anaconda Range to the north, the Beaverhead Mountains in the Bitterroot Range to the west across the Big Hole valley, and the Ruby and Tobacco Root Ranges to the east across the Beaverhead valley.

The Pioneer Mountains are essentially composed of a complex suite of igneous rocks, the Boulder Batholith, which has intruded into the much older sedimentary and metamorphic rocks of the area. The intrusion of the Boulder Batholith, along with intensive block and thrust faulting, has been the major factor in the geologic structure of the Pioneer Mountains. Present topography is the result of Pleistocene glaciation and valleyfill in the lower intermountain areas.

The northern Rocky Mountain region, prior to late Cretaceous time, was essentially a flat plain partially flooded by shallow seas. At the end of the Mesozoic Era, of which the Cretaceous is the last geologic epoch, this entire area became geologically active. Three things exemplify this activity: (1) Cretaceous uplift; (2) Late Cretaceous thrust faulting; and

(3) Late Cretaceous-Tertiary intrusive activity, i.e. the Boulder Batholith.

The regional uplifting of the continental crust brought the earth up in several north-south trending blocks. The west sides of the faulted blocks, or mountains, are higher in elevation and have characteristically abrupt scarps, while the east sides of the blocks have long, gentle slopes.

The uplifted land became subjected to erosion. As the sediments were transported downslope, they filled the intermountain valleys with debris ranging from muds and sands to gravels and cobbles. These valley-fill sediments attain a depth of several thousand feet in the axis of the mountain valleys.

Pleistocene alpine glaciation of Wisconsin Age (12,000 years before present) sculptured typical alpine glacial features including cirques, headwalls and troughs in the upper elevations of the Pioneer Mountains. In lower elevations, glacial deposits of terrace gravel, stream bed alluvium, landslide rubble, and glacial drift occur.

1.2.3 Seismicity

Boot Lake Dam (MT-823), located in the Pioneer Mountains, lies in Seismic Zone 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of potential for major damage and is based on the known distribution of damaging earthquakes in the region.

The Preliminary Map of Young Faults in the United States, by the U. S. Geological Survey (Ref. 2), indicates suspected activity along the northern expanse of the Pioneer Mountains and Holocene activity directly east, along the northwestern side of the Tobacco Root Range. The Geologic Map of Montana shows extensive faulting prior to the Cenozoic Era in the southern portions of the Pioneer Mountains.

Epicenters of local earthquakes significant enough to be reported in References 3 and 4 occur to the northeast, along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, and to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Of these two epicentral areas, the former is 75 to 100 miles northeast and the latter 50 to 150 miles southeast of the project site. Two earthquakes of significant intensity that occurred in the tri-state region southeast of the project site were the Hebgen Lake, Montana, earthquake (8 August 1959) that had an intensity of X (Modified Mercalli) and another, southeast of Dillon, Montana, and southeast of the project area (23 November 1947), that had an intensity of VIII. The three largest reported earthquakes northeast of the Pioneer Mountains have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935).

In the vicinity of the project there have been numerous other earthquakes in this century (Ref. 3 and 4). In an area bounded by the 44th and 46th parallels and by the 110th and the 112th meridians (including the tri-state region), there have been more than 50 earthquakes with intensities of V and more than 10 with an intensity of VI. The closest reported earthquakes to the project site have occurred approximately 50 miles east, near Ennis and Virgina City, Montana. The largest of these had an intensity of VI and occurred near Ennis (10 March 1977). The exact distance from the epicenter of this earthquake to the project site is not known.

The Pioneer Mountains lie in a highly seismically active area with the potential for a damaging earthquake. This warrants special attention be given to the dams that are in the area and that have been constructed without consideration of the effects of earthquakes.

1.2.4 Site Geology

Boot Lake lies in a scoured cirque basin with gentle to moderately concave slopes. A very thin mantle of weathered rock and shallow, well-drained sandy and silty loams comprise the patchy soil development in the area. The bedrock is composed of igneous and metamorphic rocks.

1.2.5 Design and Construction History

According to State of Montana records, Boot Lake Dam was completed in 1912. Construction was supervised by George Metlin, Chief Engineer for Justin E. Morse, Contractor. As plans are not available, nothing is known about the placement of material in the dam. The existing low-level outlet pipes appear to have been placed during the construction of the dam. The bridge slab on tope of the spillway structure reads: Grant Kinnison, Contractor, Dillon, Montana, 1914.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Boot Lake is located at the right abutment of the dam. The spillway is an excavated earth and rock channel with a concrete crest structure. It can be seen in Photos 7 through 12. Approximate dimensions and elevations were determined in the field for use in the calculation of the discharge capacity of the spillway.

The control section for the 22-foot-wide spillway is a 3.4-feet-high weir composed of 4 x 4 timber flashboards, which are located at the upstream end of the concrete structure. A concrete slab on top of the structure serves as a bridge for vehicles which could drive on the crest of the dam (Photo 8). The pier supporting the center of the slab is broken about 6 inches below the bottom of the slab. The concrete structure, which is 19 feet long, discharges to a rock-lined channel. Ninety-six feet further downstream, the spillway enters a concrete chute (Photo 11). The approximate slope of the rock-lined portion of the channel is 0.94%, and the concrete chute has a drop of 10 feet in 70 feet. At the end of the chute, the slope becomes almost vertical (see Plate 4 for the spillway profile).

The minimum crest elevation of the dam, 8247.3 feet, is 2.9 feet above the crest elevation of the timber flashboards, 8244.4 feet, and 6.3 feet above the crest elevation of the concrete structure, 8241.0 feet. The timber flashboards have been in place for approximately 20 years, according to U. S. Forest Service inspection reports, and are not removed or changed. They were assumed to be a permanent part of the spillway for determining the discharge capacity of the spillway for this study. The discharge rating curve (Plate 7) was computed by assuming the 4 x 4 timber flashboards act as a sharp-crested weir. The discharge capacity of the spillway, with the reservoir at the minimum crest elevation of the dam, is approximately 370 cfs.

The spillway channel appears to be in generally good condition, the only damage being some erosion damage where the rock-lined channel meets the concrete chute, some 96 feet downstream from the dam. The spillway approach channel contains a considerable amount of debris (see Photo 7), which had been retained by the log boom located about 50 feet upstream from the crest. However, the logs in the log boom were either deteriorated or missing, and the cable had broken. The debris, as it exists, does not affect the discharge capacity of the spillway. However, the possibility does exist that the debris could obstruct the spillway at higher water surface elevations if it were to move downstream in the approach channel and come into contact with the concrete crest structure.

2.1.2 Outlet

The low-level gravity outlet through the dam consists of a pair of 24-inch-diameter welded steel pipes (Photo 13, inlet; Photo 15, outlet), with vertical slide gates to control the rate of flow through the pipes. Controls for the slide gates are located on the crest of the dam (Photo 14). The conduits are approximately 130 feet long. A sketch of the dam cross section at Station 1+39, which includes the outlet pipes, is shown on Plate 3. The inlet invert elevation of both pipes is 8224.0 feet, which is 23.3 feet below the minimum crest elevation of the dam and 20.4 feet below the normal pool elevation (top of timber flashboards). The outlet invert elevation of both pipes is 8220.0 feet, and the resulting slope of both pipes is approximately 3.1%.

Because the wooden door on the top of the gate tower was padlocked shut, it was not possible to inspect the control mechanism or the gate tower. The concrete top of the gate tower is broken and spalled, and the hatch cover is rotten. A visual inspection of the upstream end of the outlet pipe revealed that the wooden-pole trash rack was in good repair and the inlet to the pipe was open and free of debris. However, the wing walls of the inlet structure are broken off from the headwall and are in danger of collapsing. The downstream ends of the outlet pipes are encased in a concrete outlet structure. The left wing wall of the structure is tilted in at the top approximately 4 inches, and the last 2 feet of the wing wall is broken off (Photo 15). The visible portions of the pipes show some signs of corrosion, but generally are in good repair and free of debris.

The outlet pipe discharge rating curve (Plate 8) was computed assuming full pipe flow discharge, no tailwater restrictions, and slide gates completely raised. The combined discharge capacity for the two 24-inch welded steel pipes is approximately 120 cfs at the normal pool elevation of 8244.4 feet, and 130 cfs at the minimum crest elevation of the dam, 8247.3 feet.

2.1.3 Freeboard

The fetch for wind-generated waves is about 925 feet and the wave run-up and set-up on the embankment is estimated to be 1.3 feet (Ref. 5). At the normal pool elevation of 8244.4 feet, an approximate 3-foot difference exists between the pool elevation and the minimum dam crest elevation. This is considered adequate in preventing wave overtopping (Ref. 6).

At the time of inspection, the lake had been drained to a level approximately 16 feet below the normal operating pool level. Under these conditions, the freeboard was adequate in preventing wave overtopping. Routings indicate that no freeboard exists during the recommended spillway design flood.

2.2 HYDROLOGY, CLIMATOLOGY AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around Boot Lake is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability

of wintertime temperatures results from the frequent occurrence of chinook winds which follow a Pacific maritime air mass invasion. The summers are characterized by warm days with low humidity and cool nights. Winters are cold and highly variable in severity from year to year and within a given year.

Dillon, in Beaverhead County at an elevation of 5218 feet, is the climatological station nearest the damsite. The precipitation and climatological data available from this station are not applicable to the damsite because of a 3024-foot elevation difference between Boot Lake and the weather station. The average annual precipitation at Boot Lake, as estimated from Soil Conservation Service graphs, is over 40 inches (Ref. 7). At the project site, the expected date of the first freeze is August 13th, and the expected date of the last freeze is July 9th (Ref. 8).

Boot Lake Dam is located on Birch Creek in the Pioneer Mountains, which are in the Beaverhead National Forest. The drainage basin above and including Boot Lake has an area of about 3.0 square miles, including the drainage areas for Pear, Tub, and Anchor Lakes which are located upstream. Basin elevations range from the normal pool elevation of 8244.4 feet to 10,193 feet on top of Tent Mountain. The average ground slope is about 15%. Basin vegetation consists of moderately thick pine and grasses on the lower basin area to sparse pine and rocky surfaces on the upper basin area (see Photos 1 and 2).

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 57 acres and a storage of approximately 980 acre-feet at the spillway crest elevation of 8244.4 feet. The spillway discharge at the minimum dam crest is approximately 370 cfs with the arrangement of flashboards observed during the inspection. The discharge capacity of the facility would increase an additional 130 cfs if the control gates of both 24-inch low-level outlets were opened.

2.2.3 Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A storm, the intensity of which approached probable maximum precipitation (PMP) intensity, did occur in parts of Montana in June 1964.

Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of one-half the PMF to the PMF. Because of the involved risk for this project, we recommend that the SDF be one-half of the PMF.

A probable maximum precipitation (PMP) storm of 24-hour duration was applied to the basin. The 24-hour, 12-hour, 6-hour and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 9) to be

15.1 inches, 12.8 inches, 10.4 inches and 6.4 inches, respectively. All 6-hour increments from 0 to 24 hours were arranged in accordance with criteria in Weather Bureau Hydrometeorological Report No. 43 (Ref.10).

The probable maximum flood was assumed to result from a PMP storm in the late spring, over hard and frozen ground. Thus, a constant soil loss rate of zero was applied throughout the 24-hour PMP storm, in accordance with Corps of Engineers recommendations. Thus, the overall configuration of the 24-hour storm is not affected by losses in the soil, and the basin rainfall is equal to the basin runoff for all storm increments. Direct precipitation onto the surface of the lake was also added with no losses.

In evaluating the PMF for Boot Lake, inflow resulting from outlet and spillway discharges and dam breaches and overflows from Pear, Tub and Anchor Lakes, located upstream, were added to the rainfall which fell directly upon the reservoir and basin to arrive at the total PMF for Boot Lake.

2.2.4 Flood Routing

For purposes of routing the probable maximum flood (PMF) through Boot Lake, the lake level at the beginning of the PMP storm was assumed to be at the spillway crest elevation of 8244.4 feet, which would correspond to the normal pool condition. The total volume of the 24-hour PMF for Boot Lake, including flows from Pear, Tub and Anchor Lakes, is 2500 acre-feet with a peak flow rate of 16,600 cfs. Two routings were made. The first routing indicated that, with the control gate of the irrigation outlet closed, the project will handle, through storage and spillway discharge, approximately 11% of the PMF volume before the dam is overtopped. The second routing assumed the control gates on the outlet pipes to be completely open. This results in the project handling approximately 17% of the PMF volume before the dam is overtopped. The dam is constructed of materials that will erode and probably fail when overtopped by floodwaters.

The PMF inflow hydrographs were developed using the SCS dimensionless unit hydrograph. These hydrographs were generated and combined using the HEC-1 (Dam Safety Version) computer program (Ref. 11). The flood routings of the PMF were made using the Modified Puls method contained in the HEC-1 program.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankment

The 27-foot-high earth dam is 288 feet long and has a crest width of 22 feet. The upstream slope is 1(V) on 4(H). The downstream slope is 1(V) on 2.6(H). Borrow for the embankment appears to have been obtained from areas above both abutments, primarily the right abutment, and from the area immediately downstream from the dam. The material exposed on the crest of the dam is a sandy silt to silty sand matrix, containing cobbles and boulders. This material is considered to be highly erodible. The upstream and downstream slopes are covered with rock riprap, generally ranging in size from 6 inches to 36 inches in diameter.

The only vegetated area of the embankment is the crest. The vegetation consists of approximately 25% coverage of native grasses and brush. There are several trees on the crest, along the upstream and downstream shoulders, which range from 2 to 10 feet tall (see Photo 3). The riprap on both slopes of the embankment is igneous rock. No evidence was found of a granular bedding or filter course between riprap and the embankment. The presence of sags or bulges on the upstream face could not be determined because of almost complete coverage by debris. Several depressions or low areas were found on the downstream face, which could have been caused by transportation of embankment material by seepage out through the riprap. The largest of these areas is roughly parallel to and 6 feet above the right abutment trough. It is about 30 feet long and begins approximately 10 feet right of the low-level outlet structure. This area can be seen above the outlet structure headwall in Photo 5. Two smaller areas, each roughly 4 to 6 feet in diameter, were found to the left of the low-level outlet, 2 to 4 feet above the elevation of the top of the outlet structure. One of these areas can be seen half-way between the man and the outlet headwall in Photo 4, on the right side of Photo 5, and in the upper left corner of Photo 6. The second of these depressions, about 25 feet left of the first, can be seen in the lower right corner of Photo 6. The cause of the depression on the right side of the outlet structure is not known. It could be the result of faulty construction control as well as seepage. However, the two smaller depressions on the left of the outlet structure appear to have been caused by concentrated seepage emerging from the embankment. The riprap from these depressions appears to have been moved downslope, while the underlying soil has been removed, leaving a dished depression.

The riprap at the top of the downstream slope was a different color from that on the remainder of the slope. This darker rock can be seen as an irregular band at the top of the embankment in Photo 4. This rock is much more weathered than the lighter-colored riprap, indicating that it probably came from a different source and was placed at a different time.

Many rodent holes were found on the embankment crest.

2.3.2 Foundation Condition, Seepage, and Drainage

The dam is probably founded on soil similar to that used in the embankment itself. This sandy to clayey silt is considered to be quite pervious. There is vegetative seepage evidence, in the form of tall weeds and even trees, in both the right and left abutment troughs and at the downstream toe. Forest Service records indicate that concentrated seeps have occurred in the left abutment and above the downstream toe at least since 1947. It is possible that there was a spring at the dam site prior to dam construction. The two depressions on the downstream face of the dam left of the outlet structure appear to have been caused by concentrated seepage through the embankment. No water was found to be flowing from any of these suspected seepage areas. Therefore, if seepage is found during periods of full pool in the reservoir, it is probably the result of flow through the foundation or the embankment. Forest Service records mention embankment seepage within 9 feet of the crest on the left side of the downstream slope.

There is no evidence to indicate that the dam includes any type of internal drain, nor is there any instrumentation, such as piezometers, installed in the dam.

2.3.3 Stability

Records indicate and visual evidence shows that there is considerable seepage through the left side of the embankment and in the abutments during periods of full pool. The seepage points to a rapidly-developing high phreatic surface. Seepage forces as well as embankment strength reduction due to saturation and submergence are cause for questioning embankment stability. From the two depressions left of the outlet structure, it appears that embankment material has been removed by seepage water. This could eventually lead to the development of a pipe and to the rapid failure of the embankment. A detailed stability analysis is not available for review. It is our opinion that sufficient information is not presently available for evaluation of stability.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Boot Lake and Dam is the responsibility of the Beaverhead Water Company, with technical assistance provided by the Forest Service. Although a formal plan for operation and maintenance of the lake and dam facilities is not known to exist, inspection reports for the years 1947, 1950, 1962, 1965, 1976, and 1977 infer the above responsibilities. In addition, the reports indicate the dam has had a history of maintenance problems, including debris accumulation, deteriorating concrete, and upkeep of appurtenances.

Access to the project is difficult. This limits regular maintenance to those functions which can be performed by hand.

2.4.2 Dam

There is no formal plan for performing periodic maintenance on Boot Lake Dam. Inspection reports and correspondence indicate a general lack of adequate maintenance for at least the last 40 years. Maintenance has been performed, but usually it has been too little and too late. Maintenance currently is needed particularly on the low-level inlet structure, the gate tower, and the concrete spillway crest structure. Proper handling of the seepage through the embankment and the abutments is also a maintenance problem.

2.4.3 Reservoir

The reservoir level fluctuates seasonally, being low in winter, full by the start of the irrigation season, and low again by autumn. Water is obtained from snowmelt and rainfall. The release of irrigation water is controlled by gate valves on the twin outlet conduits.

As with the dam, the reservoir has no formal plan for operation and maintenance and has received very little attention for many years. A large amount of debris, mostly dead trees, covers the shore of the reservoir. This debris also is partially blocking the spillway approach channel and almost completely covers the upstream face of the dam.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of Boot Lake and Dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Boot Lake Dam is classified as intermediate in size and, based on our visual inspection and judgment, has a significant downstream hazard potential. The recommended spillway design flood (SDF) for this project is 50 percent of the PMF. Based on reconnaissance level investigations, the project is incapable of handling one-half of the PMF. Boot Lake Dam, therefore, does not comply with inspection guidelines with respect to discharge and/or storage capacity.

3.1.2 Embankment Dam

As noted in Section 2.3, there is considerable evidence of seepage on the downstream slope of the embankment and along the downstream toe and the abutment troughs. The seepage in the left half of the downstream embankment face appears to have carried material from the embankment. In time, this may lead to failure of the embankment by piping. In addition, the vertical location of the seeps or boils in the left half of the downstream slope suggests that the phreatic surface in the embankment, when the pool is at the normal operating level, is considerably higher than it should be.

There are no piezometers installed in the dam. Therefore, the location of the phreatic surface cannot be determined. Also, there is no apparent system of internal drainage within the embankment.

Based on experience with similar structures and materials, the dam embankment does not conform to Corps guidelines on seepage control and seepage stability. However, sufficient information is not available with which to evaluate embankment stability.

3.1.3 Spillway

The earth and rock channel spillway was found to be in good condition with little erosion damage evident. The concrete crest structure, as best seen in Photos 9 and 10, shows some concrete deterioration as evidenced by the spalling in many locations and by the large crack in the right wall for the length of the structure. The flashboards, which the Forest Service dam inspectors recommended be removed in many of their reports, are still in place. The flashboards, and also the top slab of the crest structure, pose a threat to the safety of the dam by significantly reducing the spillway capacity. The flashboards also reduce the available flood surcharge

storage capacity of the reservoir. The log boom, located about 50 feet upstream of the concrete crest structure, appears to be inoperable and is in need of repair.

3.1.4 Outlet Works

The twin 24-inch steel pipes are generally in good condition for the age of the facility. There are signs of corrosion in the pipes, but they do not appear to be rusted through. The full lengths of the conduits were not inspected. The inlet wooden pole trash rack is in good repair, and keeps the inlet free of debris. However, the wing walls of the inlet structure are collapsing. It was not possible to fully open the access cover on the top of the gate tower on the crest of the dam (Photo 14); therefore, the interior portion of the conduit, the gate tower, and the slide gates were not inspected. However, both slide gates appear to be operational. The hatch cover is rotten and is a hazard. The concrete top on the gate tower is broken and spalled. One wing wall of the outlet structure is broken but posses no threat to the integrity of the structure.

3.1.5 Spillway and Reservoir Capacity

The reservoir storage and spillway discharge capacities are insufficient to prevent overtopping of the dam during the recommended SDF. This investigation has estimated that, during the 24-hour PMP, the dam overtops when approximately 11% to 17% of the PMF volume enters the reservoir.

3.1.6 Operation and Maintenance

Operation and maintenance are performed by the Beaverhead Water Company, with technical assistance provided by the Forest Service. There is no formal operation plan for the reservoir. Water from spring runoff and from releases out of upstream reservoirs is stored in Boot Lake and is released from the outlet as needed for irrigation. Consequently, the lake level fluctuates seasonally.

There is no formal maintenance plan for the dam, and the facility has a history of inadequate mainenance. The debris covering the upstream face of the dam, the poor condition of the low-level inlet structure, and the rodent holes and trees on the crest are all indications of the lack of sufficient recent maintenance.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test a downstream notification plan for use in the event of dam distress.

2. Repair or replace the wing walls of the low-level inlet structure.

3. Replace the concrete top slab on the gate tower and provide a new access cover.

4. Remove the flashboards in the concrete spillway crest structure to provide greater flood surcharge storage and greater spillway discharge capacity.

5. Remove debris from the reservoir area and the upstream face of the dam. Repair or replace the spillway log boom.

6. Remove the trees and their root systems from the crest of the embankment and adequately backfill and compact the resulting holes.

7. Eliminate rodent populations on the embankment and repair existing rodent damage.

8. Inspect the entire length of the outlet conduits and repair as necessary.

9. Conduct more-detailed hydrologic and hydraulic routing studies, involving all four of the Beaverhead Water Company's Birch Creek watershed dams, to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate.

10. Investigate seepage and embankment stability. The study should be performed by a qualified and experienced geotechnical engineer. Modify the embankment as studies indicate.

11. Replace the spillway or repair all cracks and spalled concrete and remove the structure's top slab or replace the supporting pier.

12. Develop and implement a periodic maintenance plan for the dam and appurtenant structures. Because of the remoteness of the project site, the maintenance plan should include frequent condition inspections whenever water is impounded.

13. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation , and maintenance of earth dams.

Prior to performing engineering studies and remedial construction, coordinate all work with the U.S. Forest Service and the Montana Department of Natural Resources and Conservation to insure compliance with all laws and regulations.

REFERENCES

1. U. S. Army Corps of Engineers, Office of the Chief of Engineers, Report to the U. S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspections of Dams", Washington D. C., Department of the Army, May 1975.

2. Howard, K. A., et al, "Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity," U. S. Geological Survey, Reston, Virginia, 1978.

3. U. S. Geological Survey, "Earthquake Information Bulletin," Washington D. C., 1973-1978.

4. U. S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington D. C.

5. U. S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-up on Reservoir Embankments," Engineer Technical Letter No. 1110-2-221.

6. U. S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, Water Resources Technical Publication, U. S. Government Printing Office, Washington D. C., 1974.

7. U. S. Department of Agriculture, Soil Conservation Service, "Average Annual Precipitation in Montana," Portland, OR, 1977.

8. Caprio, J. M., "Montana: Average Dates of Freeze," Folders No. 81, 82, and 83, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana, March 1965.

9. U. S. Department of Commerce, Weather Bureau, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Technical Paper No. 38, U. S. Government Printing Office, Washington D. C., 1960.

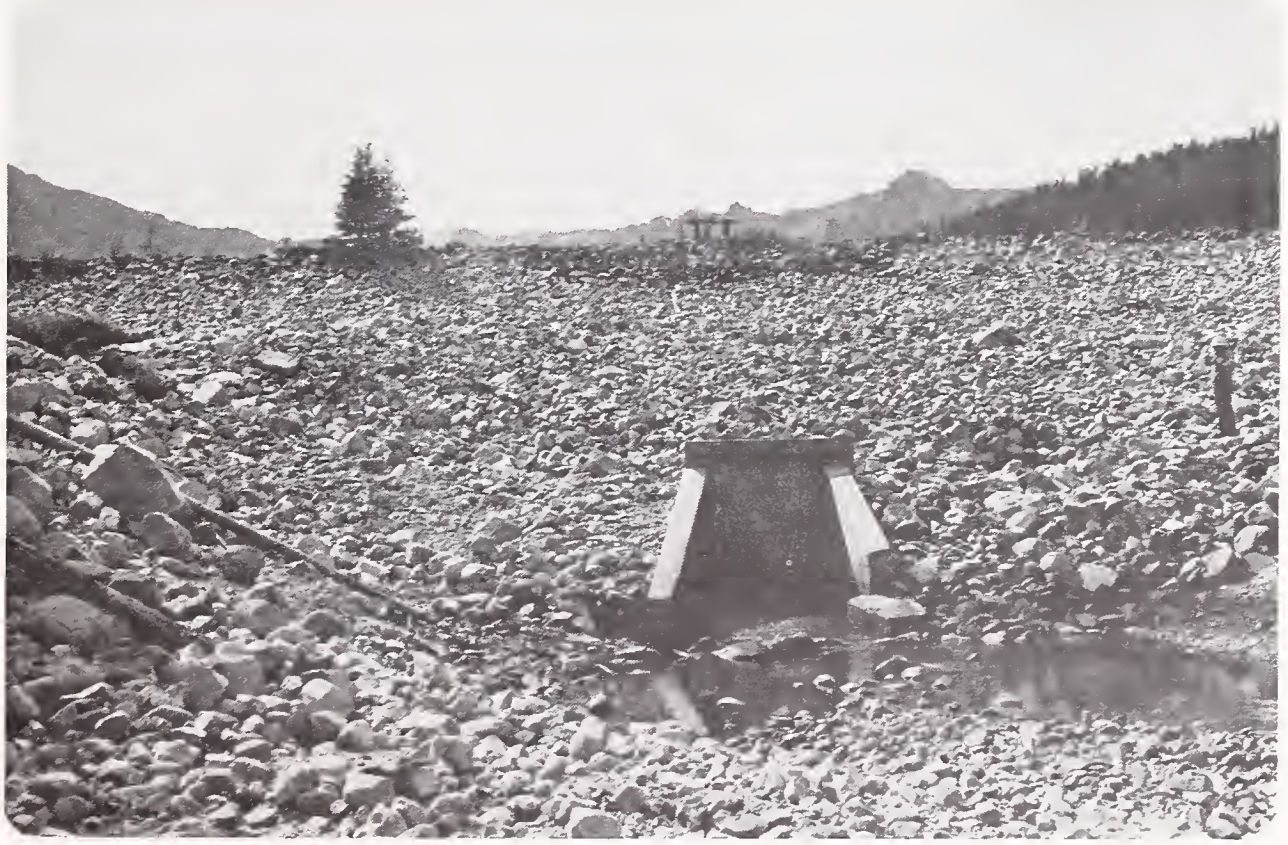
10. U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, Washington, D. C., November 1966.

11. U. S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users' Manual for Dam Safety Investigations, Davis, California, September 1978.

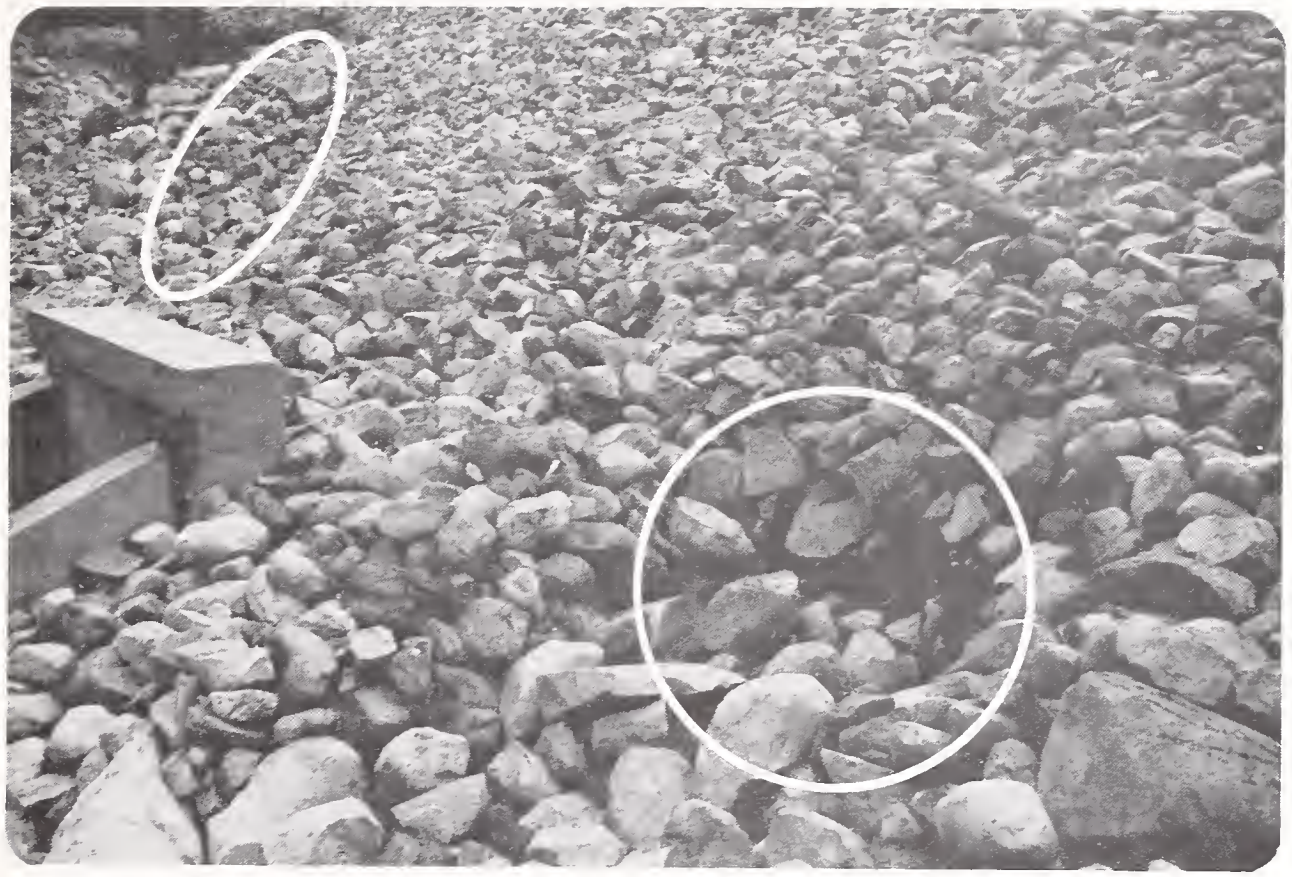
(PHOTO 1) Boot Lake and Dam, Overview Looking Upstream

(PHOTO 2) Boot Dam, Upstream Face

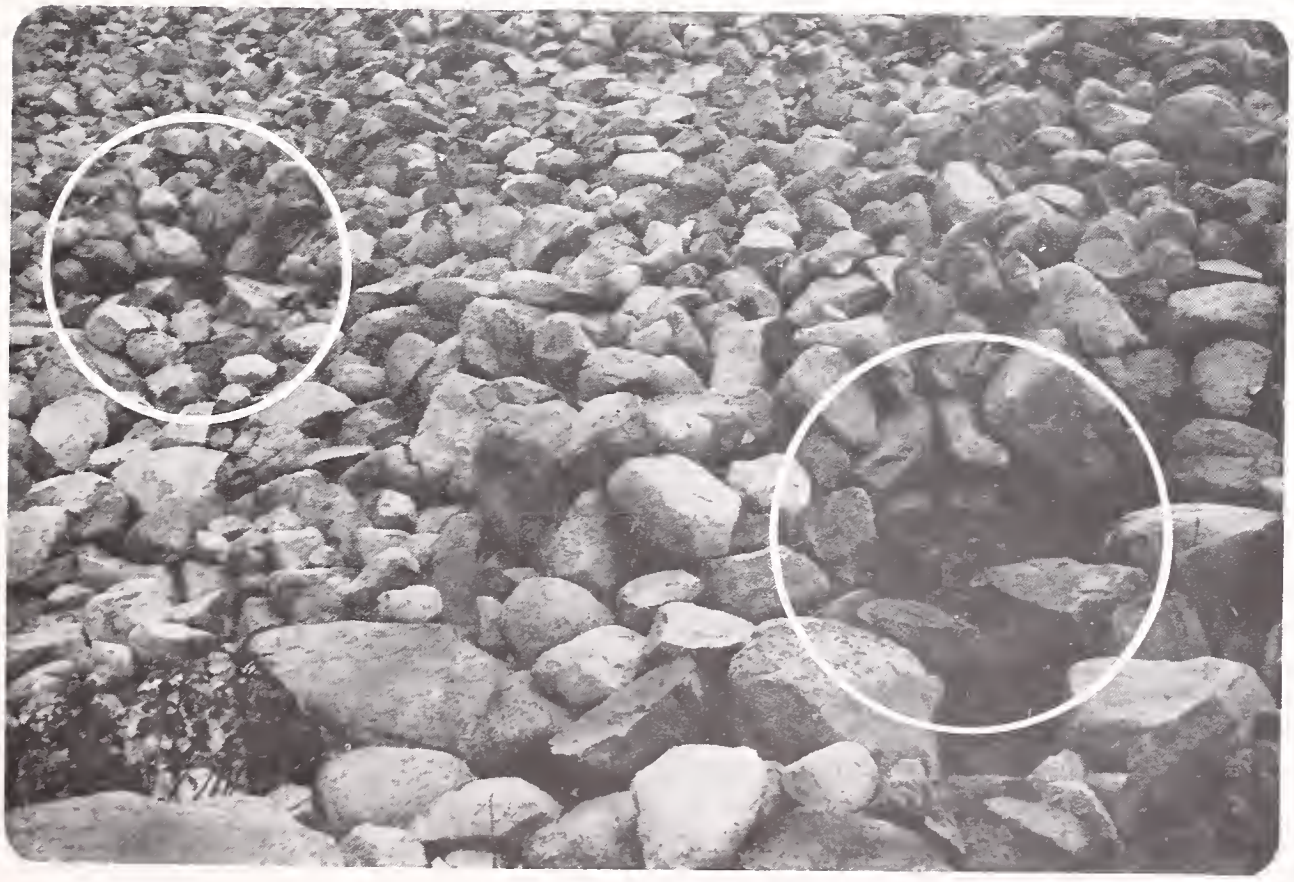
(PHOTO 3) Crest and Downstream Face from Right Abutment



(PHOTO 4) Downstream Face and Low-Level Outlet Structure



(PHOTO 5) Seepage Area on Downstream Face Left of Outlet Headwall and Depression Right of Outlet Headwall

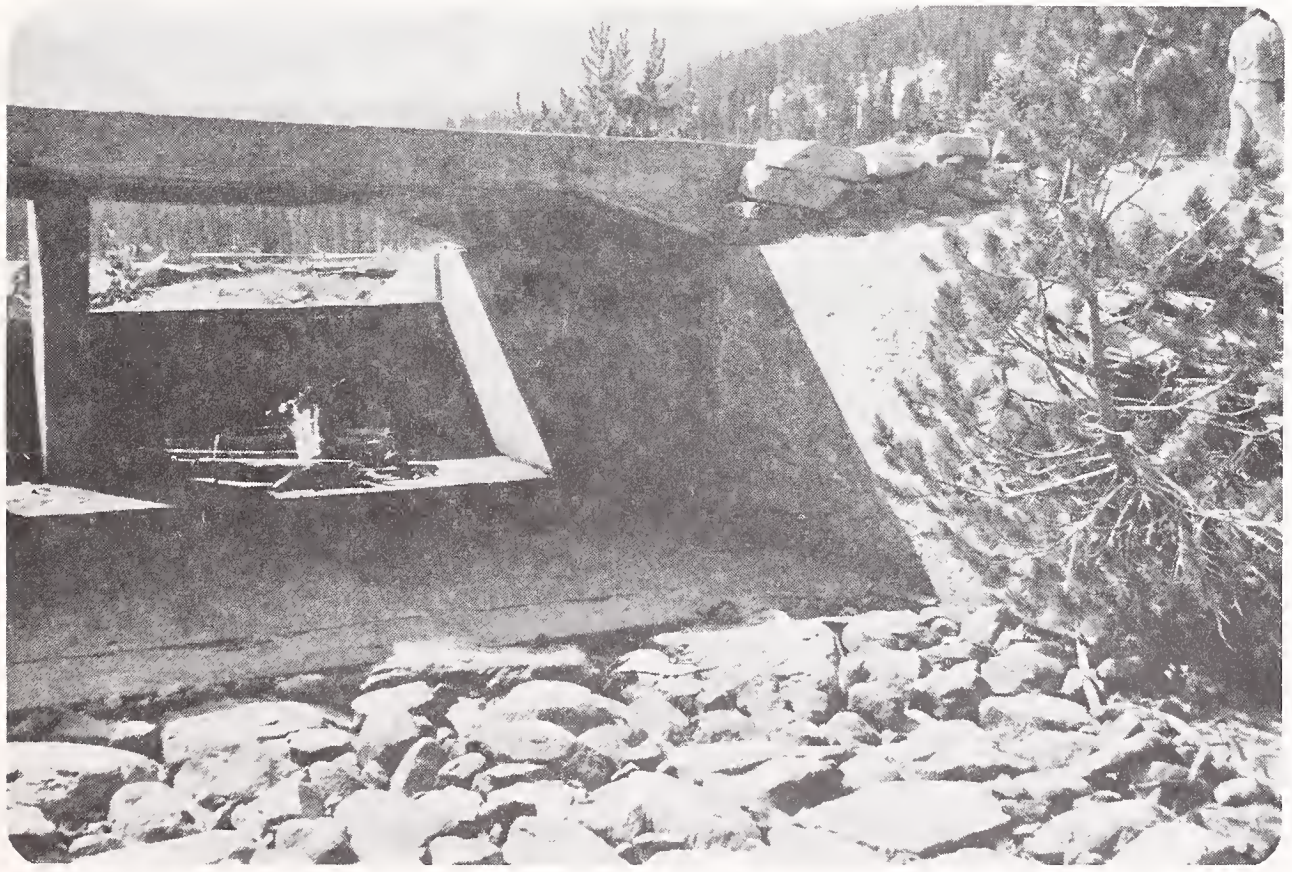


(PHOTO 6) Seepage Areas on Downstream Face
(Seepage area in Photo 5 is in the upper left corner)

(PHOTO 7) Spillway Approach Channel, Looking Upstream From Control Structure

(PHOTO 8) Spillway Channel and Control Structure from Upstream Side

(PHOTO 9) Control Structure, Right Side From Downstream

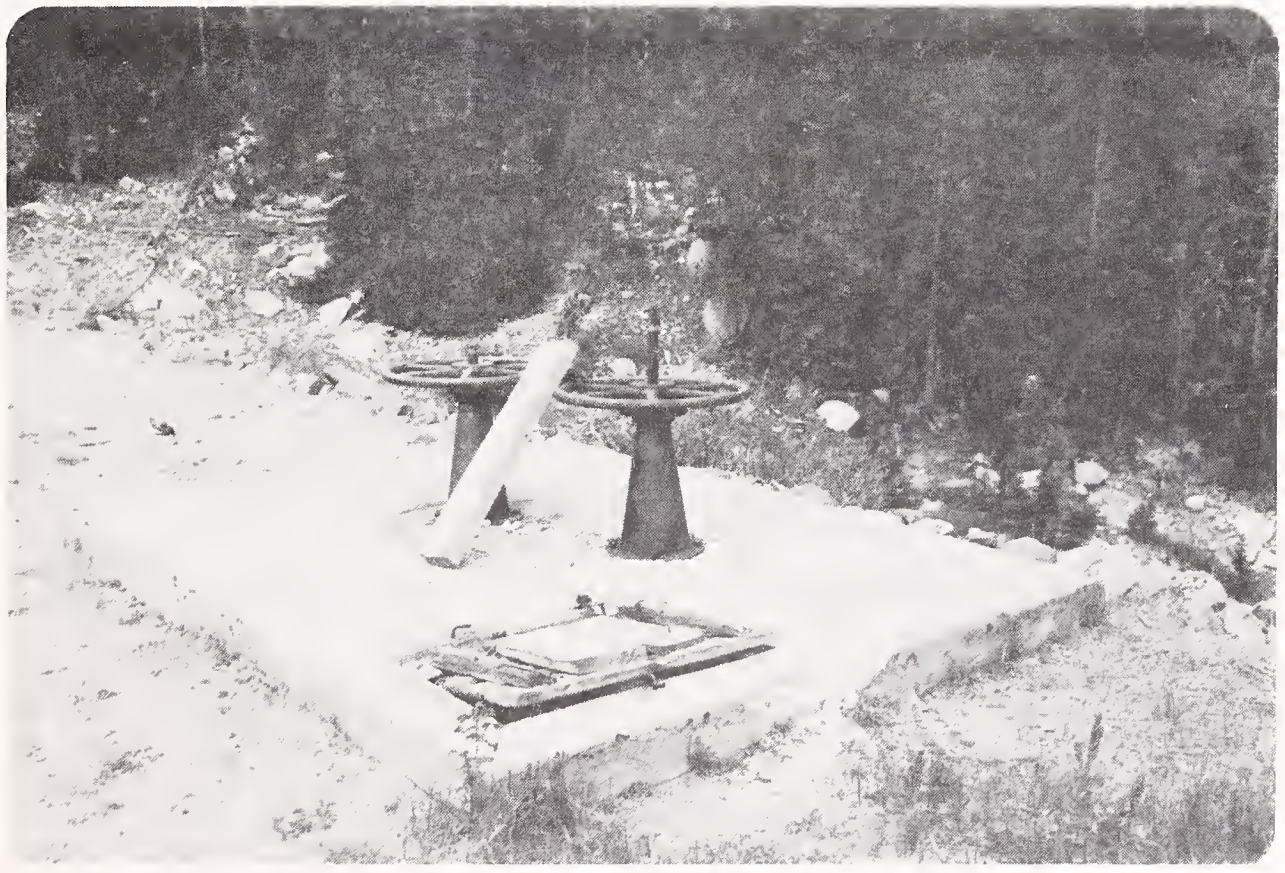


(PHOTO 10) Control Structure, Left Side from Downstream

(PHOTO 11) Spillway Outlet Channel, Looking Downstream from Control Structure

(PHOTO 12) Spillway Outlet Channel, Concrete Section, Where it Rejoins the Stream

(PHOTO 13) Low-Level Inlet Structure and Wooden Pole Trash Rack

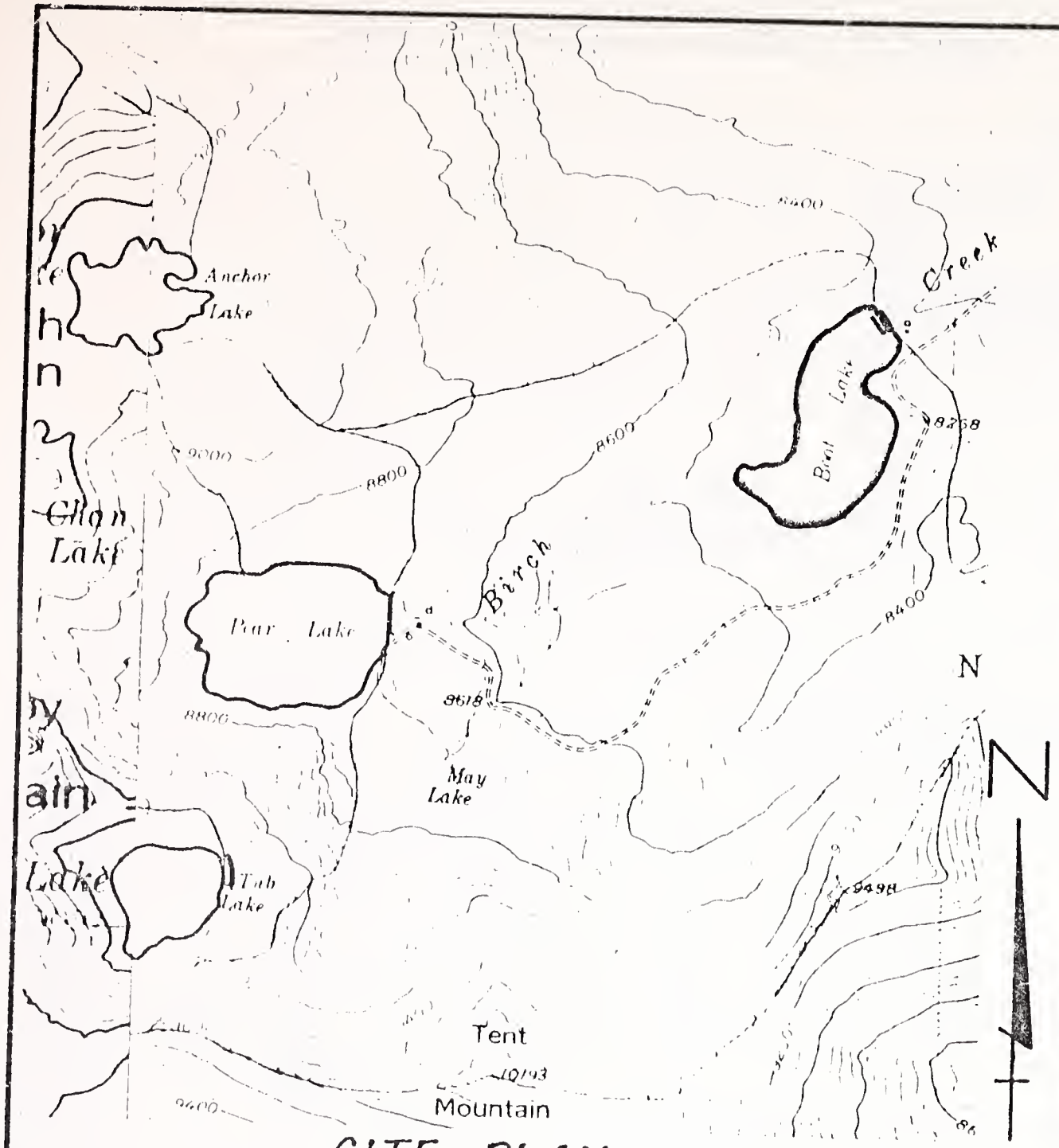


(PHOTO 14) Outlet Controls and Top of Gate Tower on Dam Crest

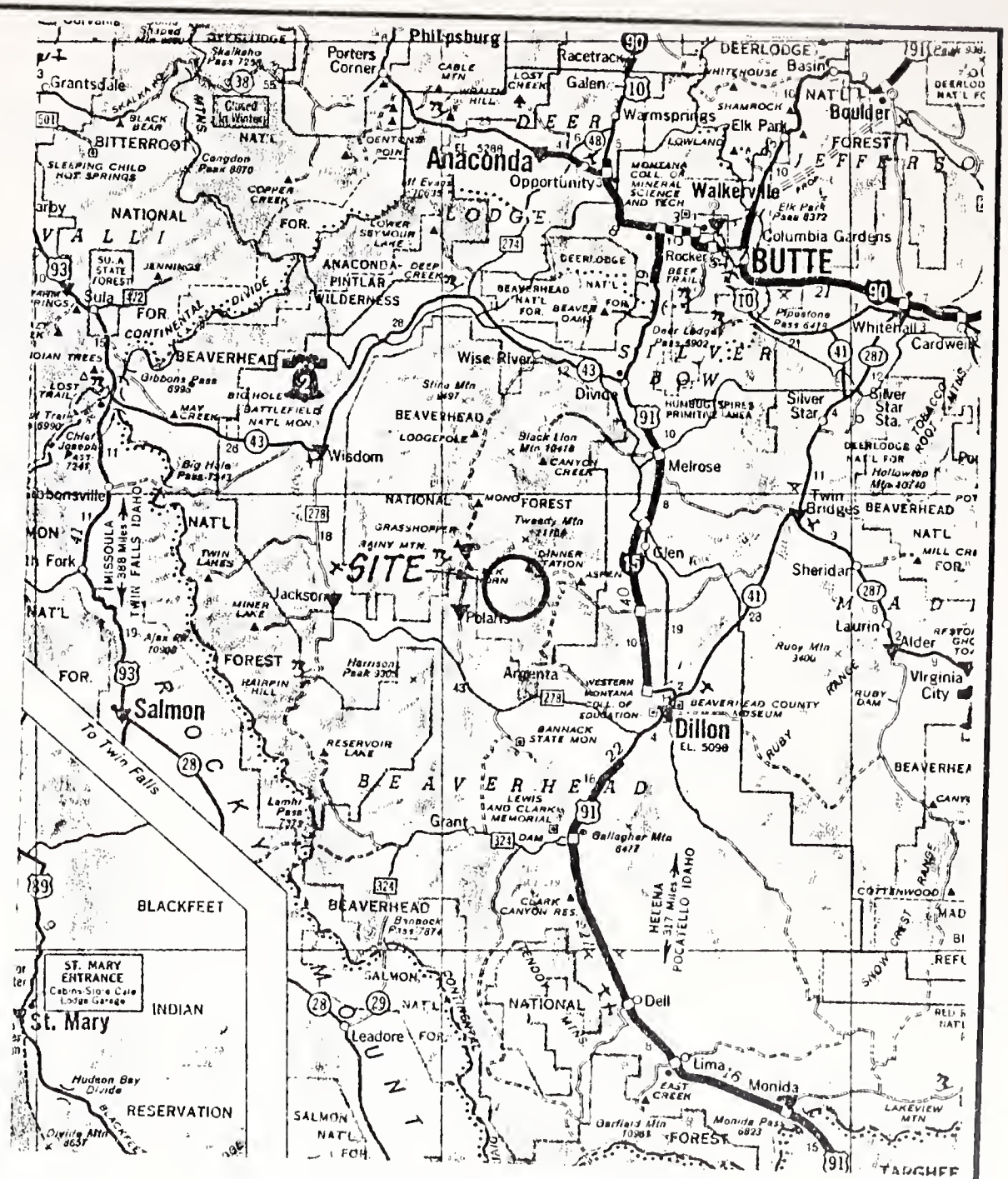
(PHOTO 15) Low-Level Outlet Structure

(PHOTO 16) Looking Downstream from Crest of Dam

(PHOTO 17) Former Weir Structure Downstream from Dam



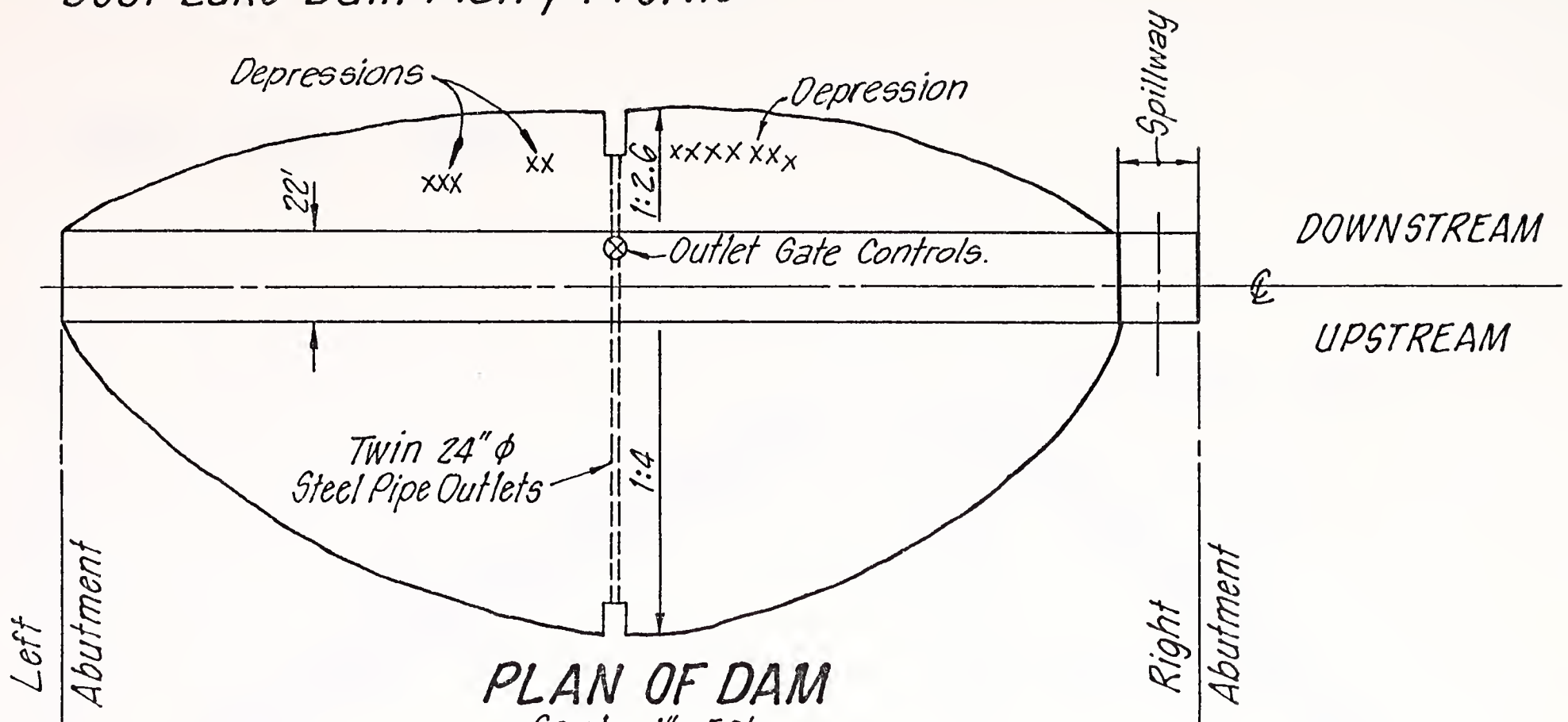
SITE PLAN



VICINITY MAP

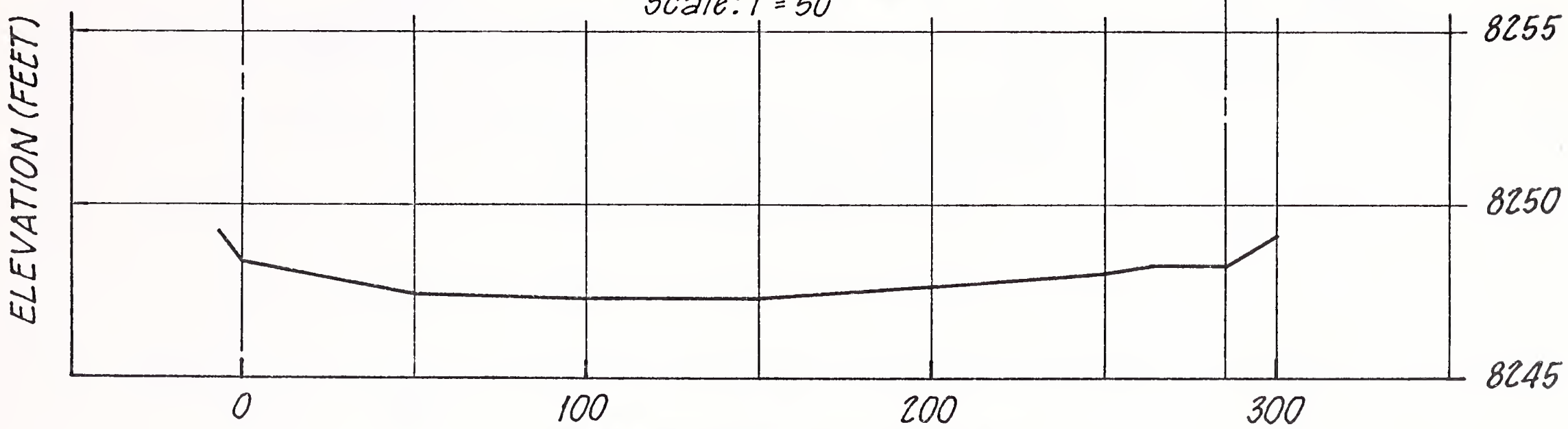
PLATE 1
BOOT LAKE DAM (MT-823)
SITE PLAN & VICINITY MAP

Boot Lake Dam Plan & Profile



PLAN OF DAM

Scale: 1" = 50'

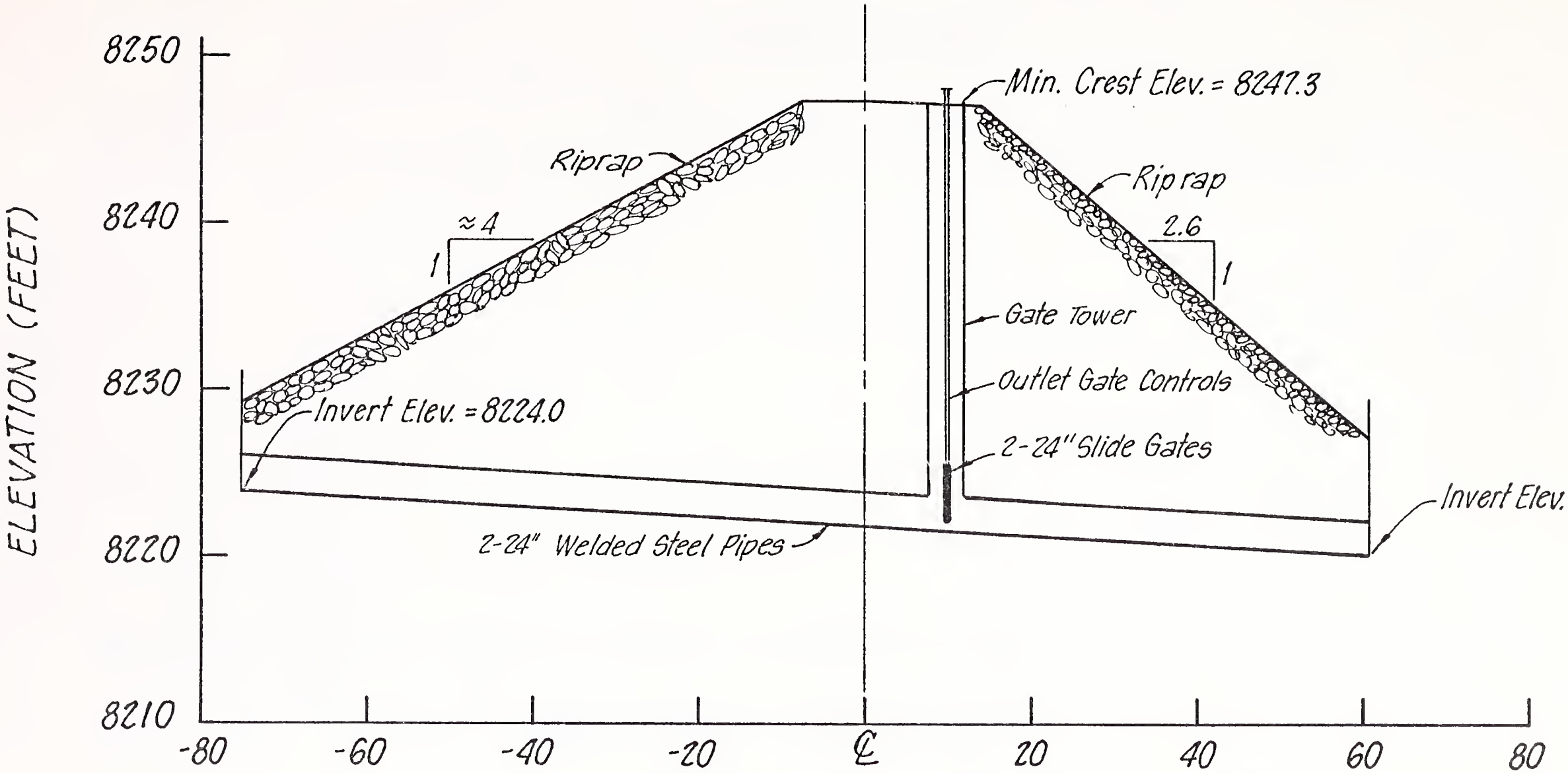


DAM CENTERLINE PROFILE

Scale: 1" = 50' Horiz.
1" = 5' Vert.

PLATE 2

BOOT LAKE DAM

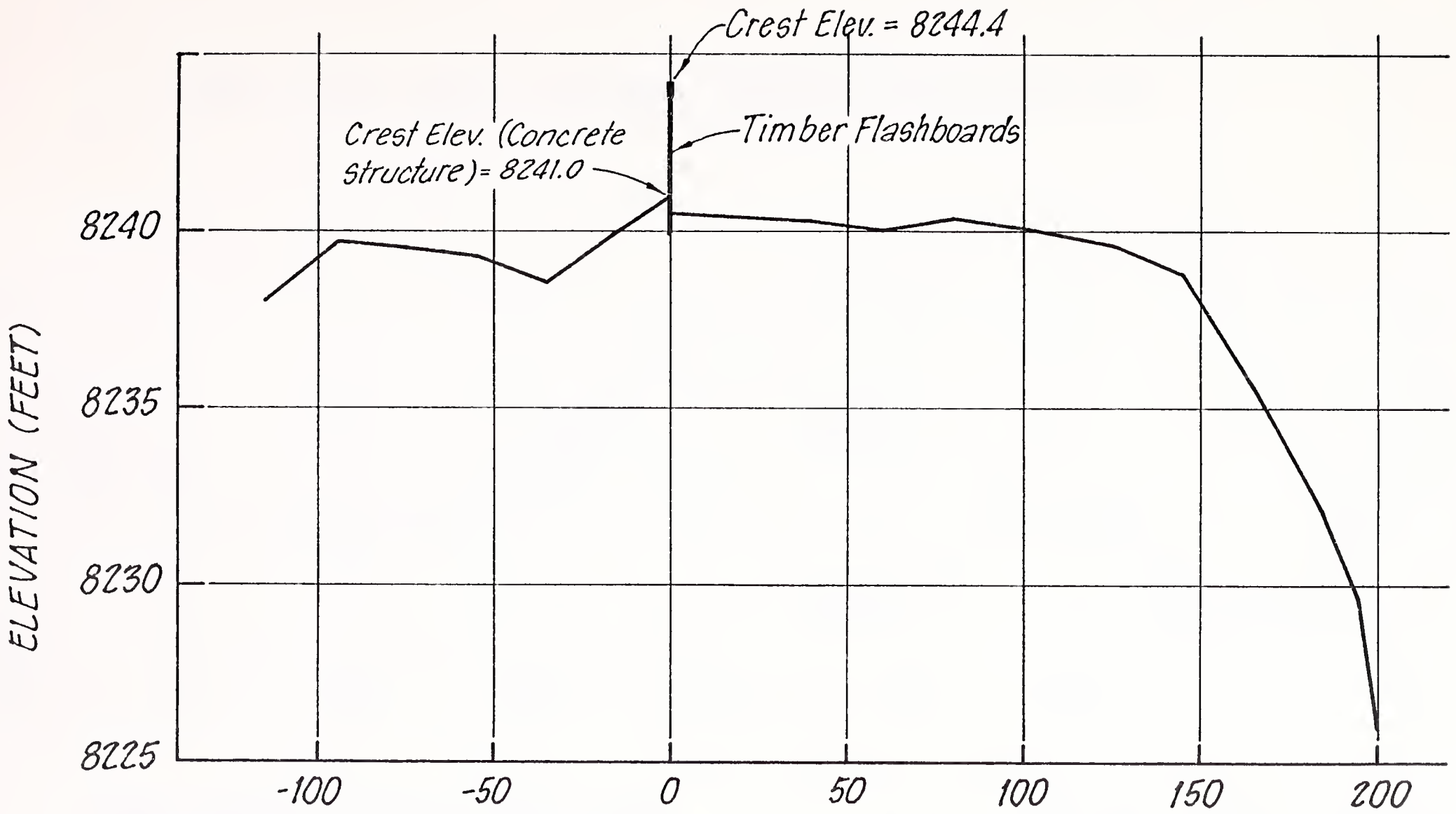


DAM CROSS-SECTION @ OUTLET

Scale: 1" = 20' Horiz.
1" = 10' Vert.

PLATE 3

Boot Lake Dam Spillway

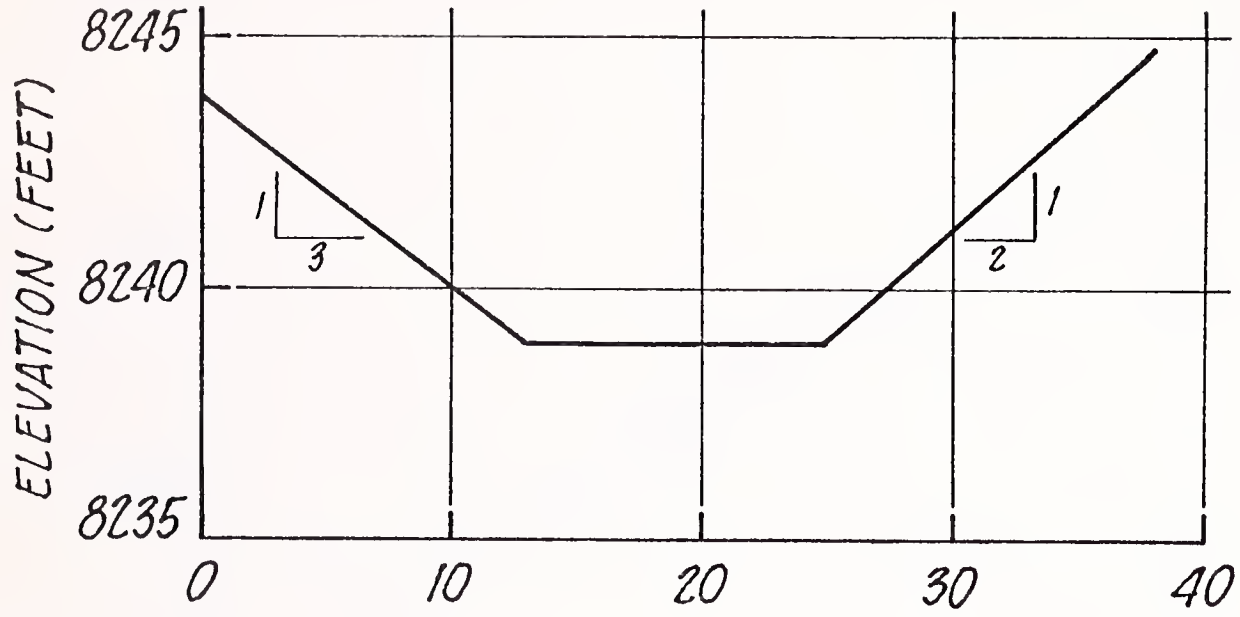


SPILLWAY PROFILE

Scale: 1" = 50' Horiz.
1" = 5' Vert.

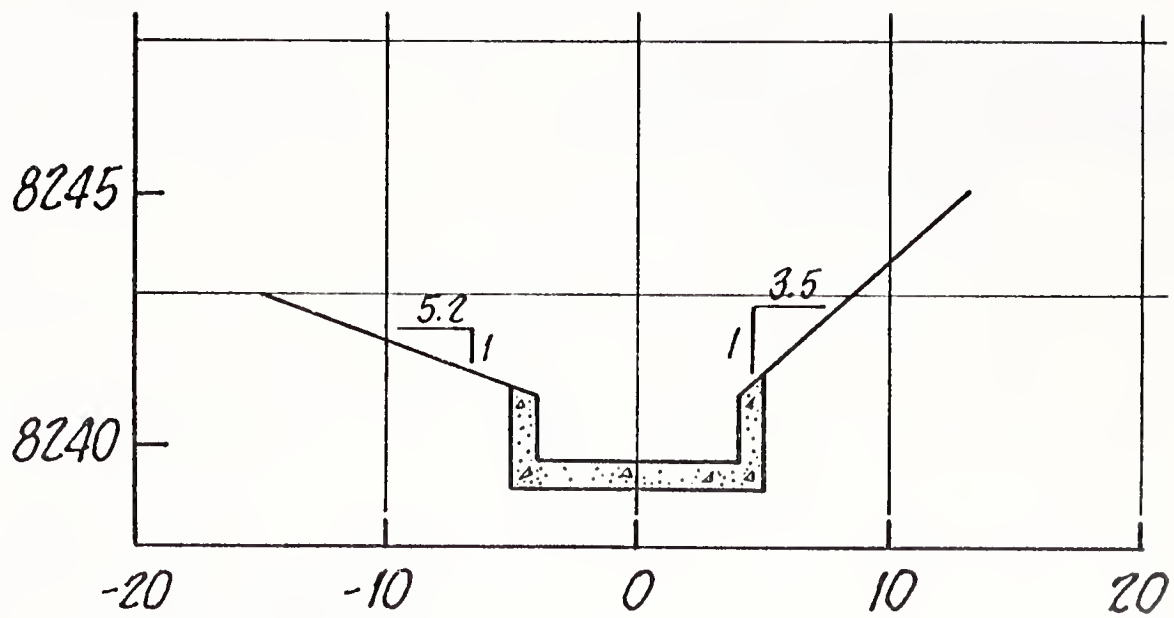
PLATE 4

Boot Lake Dam Spillway & Chute Cross-Sections



SPILLWAY CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.



CHUTE CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.

PLATE 5

WATER SURFACE AREA (ACRES)

90 80 70 60 50 40 30 20 10

8250

Min. Dam Crest Elev. = 8247.3

8245

Spillway Crest Elev. = 8244.4

8240

8235

8230

8225

8220

ELEVATION (FEET)

Elev. vs. Vol.

Elev. vs. S.A.

BOOT LAKE DAM
ELEV.-AREA & STORAGE
CURVES

0 150 300 450 600 750 900 1050 1200 1350

TOTAL STORAGE VOLUME (ACRE-FEET)

PLATE 6

SPILLWAY DISCHARGE CURVE
BOOT LAKE & DAM

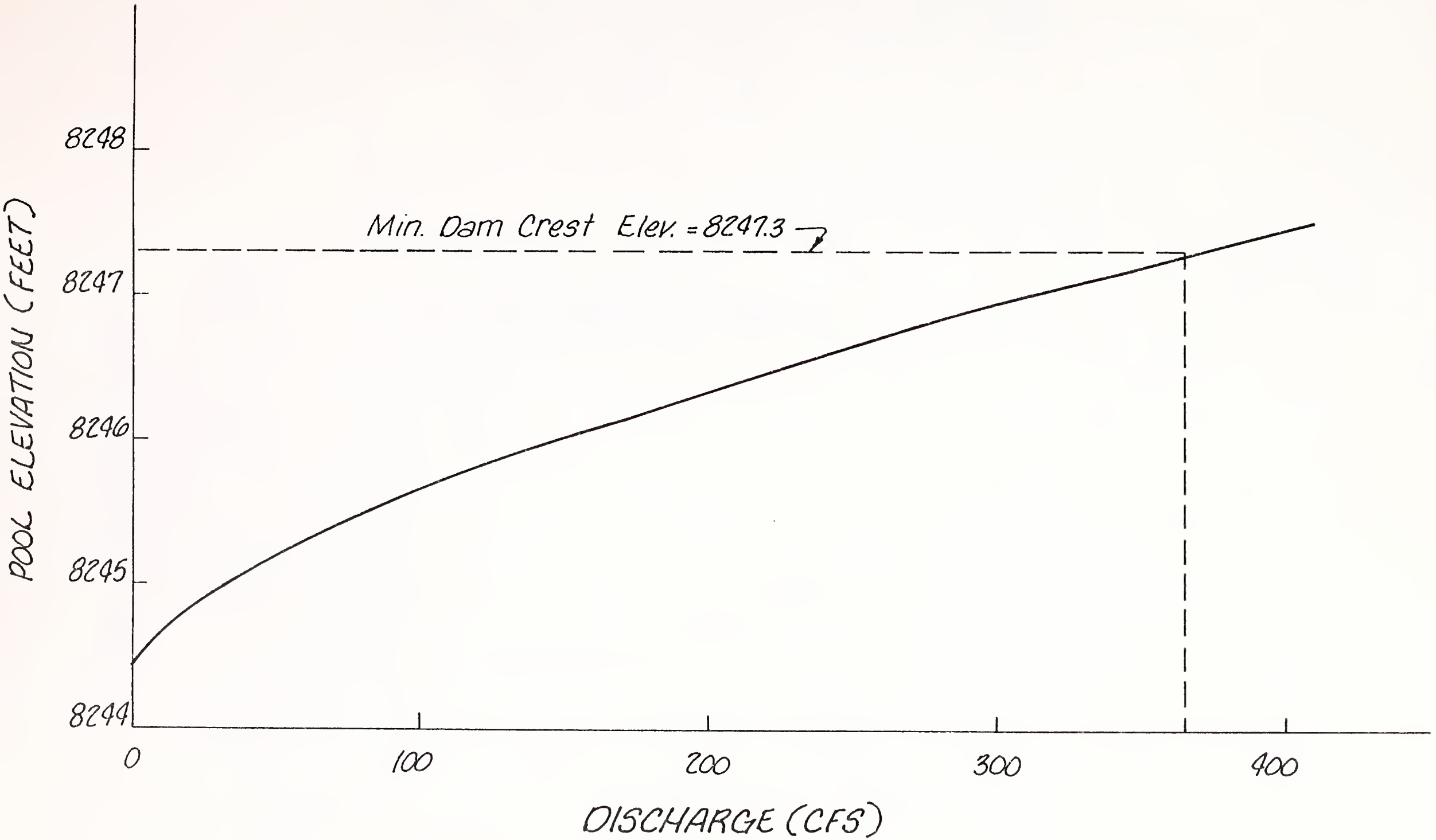


PLATE 7

TWIN 24" ø STEEL CONDUIT OUTLETS
COMBINED DISCHARGE RATING CURVE
Boot Lake ₵ Dam

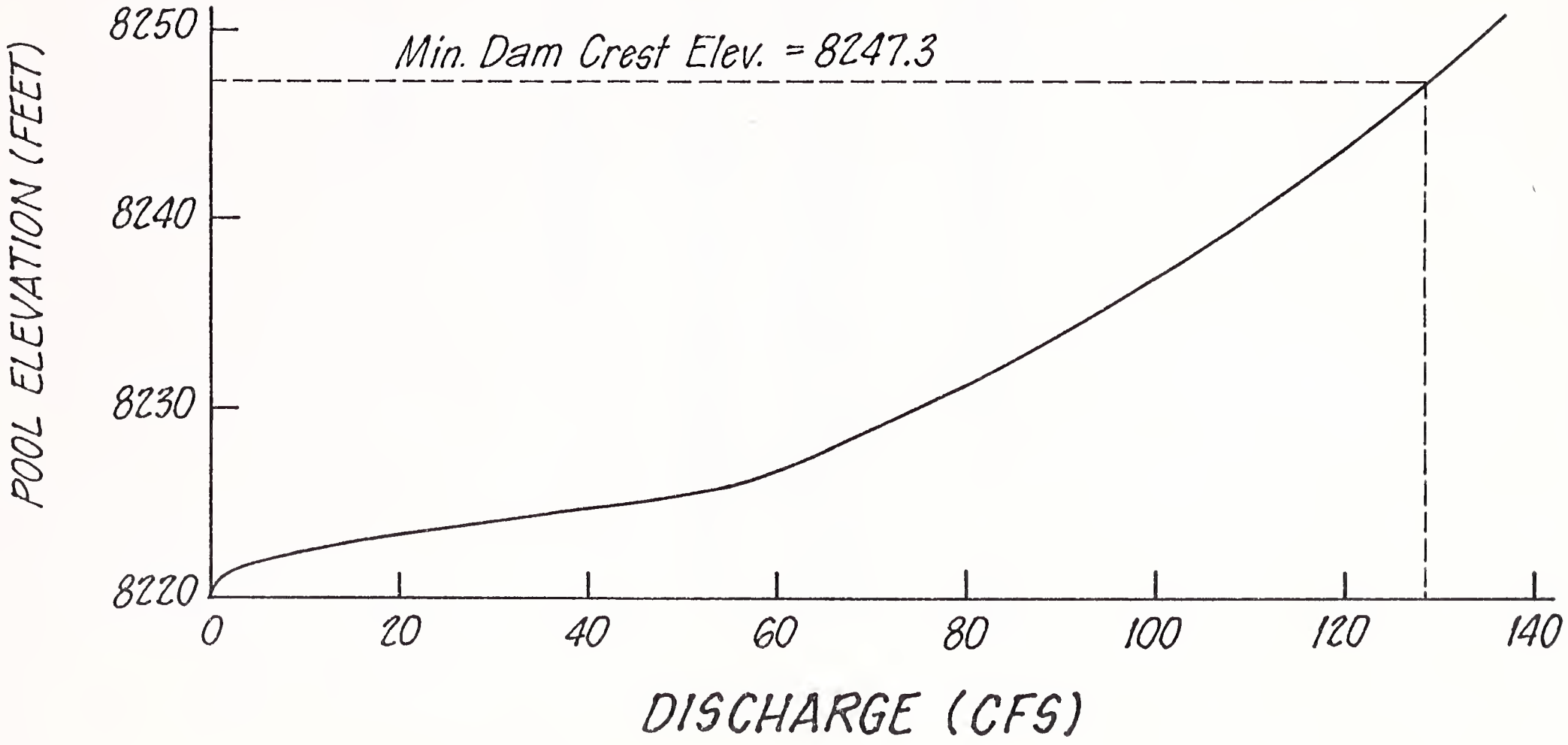


PLATE 8

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 11, 1980

Department of the Army
Seattle Distric, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Inspection Report on Boot Lake Dam (MT-823).

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Boot Lake Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

AN EQUAL OPPORTUNITY EMPLOYER

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59807

7530

DEC 19 1980

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle Washington, 98124

Dear Mr. Knutson:

We have reviewed the final draft report for the Phase I inspection of Boot Lake Dam and have the following comments.

We agree a more detailed hydrologic analysis, including a breach dam routing, is needed to better define the hazard this dam and others in the Birch Creek drainage present.

Sincerely,

Beryl Johnston

BERYL JOHNSTON
Acting Director
Engineering

IN REPLY REFER TO:
9100 (941)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
222 North 32nd Street
P.O. Box 30157
Billings, Montana 59107

DEC 16 1980

Mr. Sidney Knutson, P.E.
Asst. Chief, Engineering Division
Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

Final drafts for Phase I Safety Inspection and Evaluation reports for Tub Lake and Dam Project, MT-822; Pear Lake and Dam Project, MT-820; Anchor Lake and Dam Project, MT-821 (South) and MT 1483 (North); and Boot Lake and Dam Project, MT-823 all located in Beaverhead County, Montana have been reviewed.

We have no additional information or comments to add to the draft reports. The opportunity to review the reports is appreciated.

Sincerely yours,

Henry T. Hammersmark

Henry T. Hammersmark
Chief, Branch of Engineering

BEAVERHEAD WATER COMPANY

Dillon, Montana

6825 Highway 91 North
Route 1
Dillon, Montana 59725

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Subject: Tub, Pear and Boot Lake Dams
MT-822, MT-820, MT-823

Dear Mr. Knutson:

Enclosed for your consideration are our review comments on the Phase I Inspection Report on the subject dams. We hope they will be of value to you in preparation of the final report. They were made in consultation with Stensatter Druyvestein and Associates, Consulting Engineers, Missoula, Montana.

We wish to thank you for the opportunity to make comments and look forward to cooperating in efforts to improve water resource development.

Sincerely,

Garth Taylor, President
Beaverhead Water Company

Enclosures

December 1980

REVIEW COMMENTS
by
Beaverhead Water Company, Dillon, Montana
on
Phase I Inspection Report
Boot Lake Dam
Beaverhead County, Montana

MT-823

The Beaverhead Water Company is grateful for this opportunity to comment on the Phase I Inspection Report on the Boot Lake Dam. We are vitally interested in this dam as productivity of lands owned by members of our Company are highly dependent on safe, reliable water storage. Although maintenance of the dam to supply irrigation water is paramount, it is also important to recognize the additional benefit of providing some flood control storage.

We recognize our obligations for providing safe water storage consistent with reasonable criteria for the size of structures and hazards involved. However, because the West Bench Irrigation District is heavily obligated to the Federal Government for loans on a new gravity sprinkler system, it has very limited available funds. Therefore, it is very important that any required work be really necessary and consistent with actual conditions.

The following comments are made for consideration in preparation of the final report.

I Inspection and Safety Criteria

The value of guidelines for implementation of the National Dam Inspection Program is recognized as being very important. We generally agree with provisions in the "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers. But we feel it is equally important to recognize and remember the basis for use of these guidelines. As noted in the Preface to these guidelines, "Safety must be evaluated in the light of peculiarities

and local conditions at a particular dam... The establishment of rigid criteria or standards is not intended." The Preface further states that the "guidelines are intended to be flexible" and contains the following paragraph:

> "Conditions found during the investigation which do not meet guideline recommendations should be assessed by the investigator as to their import from the standpoint of the involved degree of risk. Many deviations will not compromise project safety and the investigator is expected to identify them in this manner if that is the case. Others will involve various degrees of risk, the proper evaluation of which will afford a basis for priority of subsequent attention and possible remedial action."

Therefore, as will be pointed out in more specific comments, we think that evaluations and recommendations for each dam should be consistent with the particular circumstances.

II Inspection

The primary purpose of Phase I investigations is to identify those dams which may pose hazards to human life or property. This is good. However, we are not pleased with far reaching safety evaluations and costly recommendations based on a brief site visit. We think that if potentially serious conditions exist, or if costly recommendations are made, then they should be made based on a more thorough investigation and analysis by experienced engineering personnel. In this case, they should have a background in high mountain dam construction and hydrology. This is consistent with the intended use of the guidelines.

III Existing Dam

It is important in any investigation and evaluation of a dam to keep in mind the difference between new design criteria and evaluation criteria for an existing structure. In some aspects they are similar or even identical, but in others they are different. For example, slope stability of a dam 75 years old in this case, can be based primarily on actual experience or observation rather than an estimate based on laboratory tests. Here again experience is important as many other dams in Western Montana are constructed of similar or identical soils. As another example, the need for and value of installing and monitoring piezometers is highly questionable.

IV Classification

The hazard potential classification of "significant" is based on "...approximately 2 inhabitable structures located about 10 miles downstream from Boot Lake ..." We question the accuracy of this rating and believe it should be "low". Was a flood routing done past these structures? Were cross sections and elevations taken near these structures to determine if loss of life would be expected if they were occupied? Are they in fact used or inhabited a significant amount of time?

This is highly important as the degree of risk affects spillway capacities, freeboards and other features on these and other dams.

V Hydrology

In general, we believe that the hydrologic analyses performed under this study are inadequate to serve as a basis for any significant changes in the dams, spillways or hazard ratings. We agree that not enough is known about high mountain basin hydrology to accurately predict exact storm or snowmelt runoff. But we don't agree that an ultra conservative approach should be

followed because of this lack of knowledge or data. To begin with, we think a Q_{100} evaluation flow is much more realistic for a low hazard structure such as this. The guidelines recommend Q_{50} to Q_{100}.

With regard to a Probable Maximum Flood (PMF) analysis, to go from Probable Maximum Precipitation (PMP) to PMF with no infiltration or other deductions certainly is conservative, but not necessarily realistic for this situation. Also, the basis for using a 24-hour PMP is unknown and unsupported. Further, we disagree with the inclusion of storage waters from upstream lakes in the inflow hydrograph for this reservoir.

In summary, we think that for small projects such as this one, that appropriate "safe flood rating criteria" should be established at somewhat less than new design criteria. It doesn't seem reasonable to totally ignore the 65 years that this project has experienced.

VI Flood Warning System

Considering the size and remote, unattended location of these dams, and the determination that only "approximately 2" inhabitable structures would be directly affected by a dam failure, the recommendation to "Immediately develop, implement, and periodically test an emergency warning system..." seems totally inappropriate. If there was any advance notice, it would seem that the best plan would be to directly notify anyone living along the stream in person or through the sheriff's department.

VII Maintenance and Repair Recommendations

These are generally acceptable except for items previously covered and for the following:

a. Based on a low hazard rating and a revised hydrologic analysis, the existing spillway flashboardsmay be acceptable. They are important for irrigation water storage so if absolutely necessary, a reduction in height or design modification may be appropriate rather than total removal.

b. It may not be necessary, practical or feasible to remove all root systems from bushes and trees. The extent of work should be determined by an experienced engineer based on a careful inspection and assessment.

The remoteness of the site make inspections, maintenance and repairs difficult and expensive, but we agree that improvements can be made in these areas.

Beaverhead Water Company

Garth Taylor, President

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

26 January 1981

Garth Taylor, President
Beaverhead Water Company
6825 Highway 91 North
Route 1
Dillon, Montana 59725

Dear Mr. Taylor:

Thank you for providing comments on the draft dam safety reports for your company's dams: Anchor Lake Dams, MT-821 and MT-1493; Tub Lake Dam, MT-822; Boot Lake Dam, MT-823; and Pear Lake Dam, MT-820. Your comments have been considered in preparation of the final reports and all your comments will be appended to the final reports.

I am gratified that you and your company have such a keen interest in dam safety and I share your view about properly maintaining the structures without having to do unnecessary engineering studies or remedial work.

The inspections were conducted by experienced engineers who used the inspection guidelines developed by the Corps of Engineers in consultation with states and other engineering organizations, both within and outside the Government. The guidelines are used as a screening tool to determine if existing dams are in need of further study and/or remedy. The Corps of Engineers has no enforcement authority in implementing report recommendations.

The inspecting engineers used judgement in arriving at the downstream hazard classification for your dams. Because the downstream hazard potential is so important to what a dam's capability must be in controlling floods, we have recommended that additional basin hydraulic and hydrology studies be undertaken by you to better define the interrelationships of your dams and the potential hazards of dam failure and to base each project's needed flood handling capability on that more in-depth study. This study should form the basis for all safety-related activities at each site. Both the United States Forest Service and the Montana Department of Natural Resources and Conservation's Engineering Bureau concur in this approach.

NPSEN-FM
Garth Taylor, President

Your concern about our recommendations on downstream warning plans is well taken. Our intent here is to have some workable plan to promptly notify the downstream residents and interests in case of dam distress. We are not advocating any alarm system such as sirens, etc. Your idea of having the affected parties notified by the Sheriff or someone designated for that purpose is the kind of plan we meant, but it should be a formal written and coordinated plan showing who has responsibility.

Sincerely yours,

Sidney Knutson